70 YEARS OF CREATING TOMORROW

Los Alamos NATIONAL LABORATORY

Summary of Recent LANL Progress in the IE, T&E, ND, and IP&D Elements of NCSP

Bob Little, Bill Myers, Skip Kahler, and Jeff Favorite

NCSP FY13 Technical Review

May 30, 2013

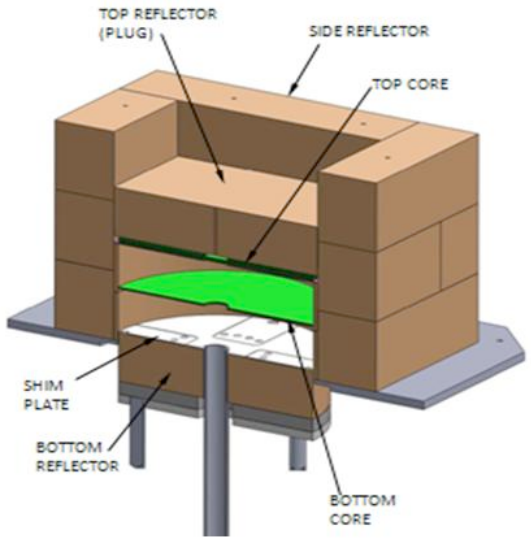
LA-UR-13-23851

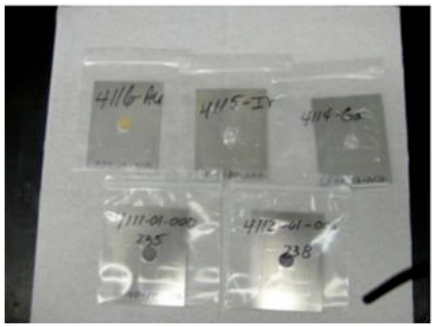
Outline

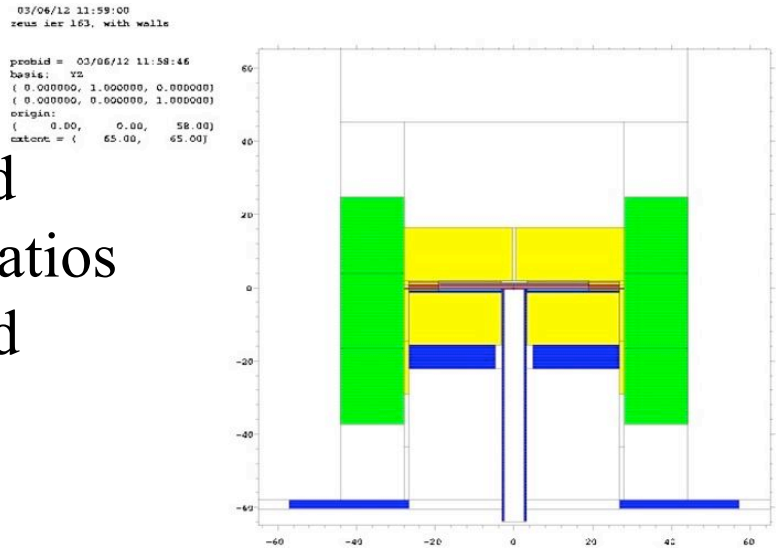
- **Integral Experiments**
- Training & Education
- Nuclear Data
- Information Preservation & Dissemination

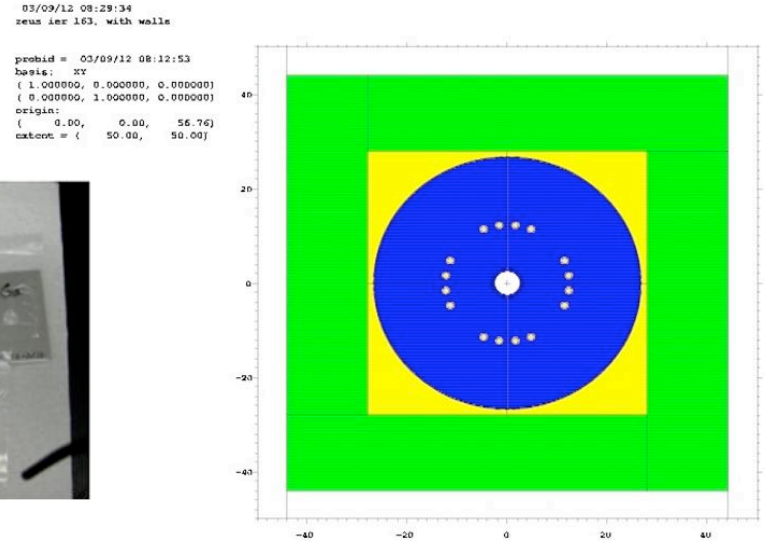
IER 163: Radiochemistry Results from the COMET (Zeus) Irradiation

Final report (LA-UR-13-22320) comparing experimentally determined spectral indices and other activation ratios with simulation results was completed





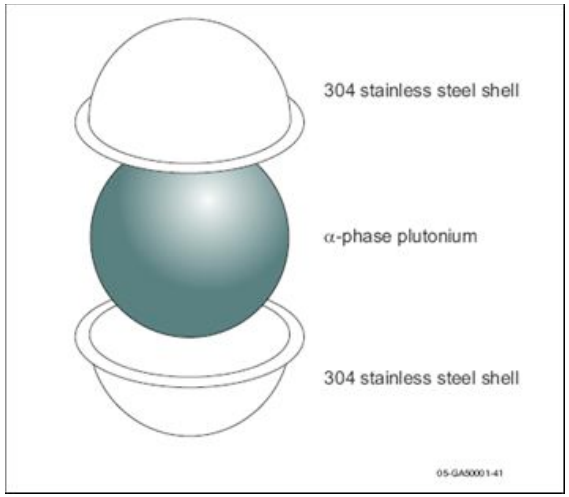


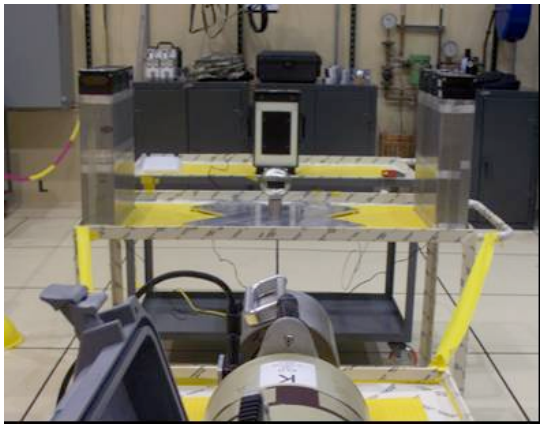


IER 160 and 161 Subcritical Benchmarks Using the BeRP Ball

IER 160 is Tungsten Reflected

IER 161 is Nickel Reflected



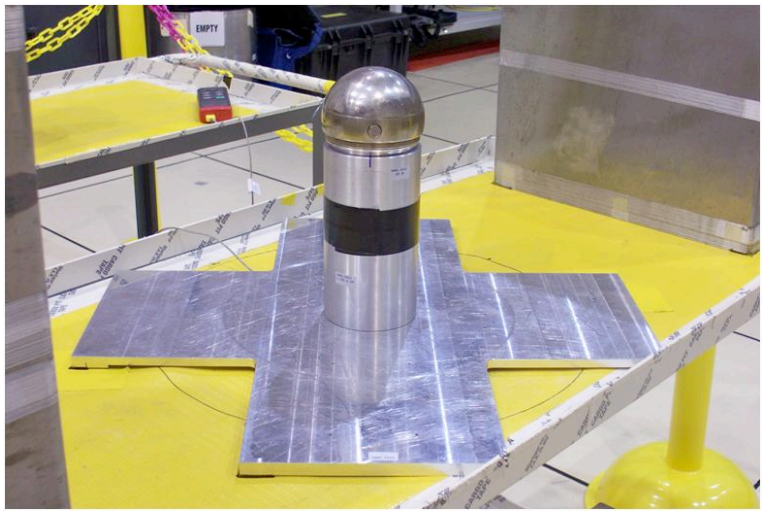


Data being used to validate MCNP list-mode subroutine.

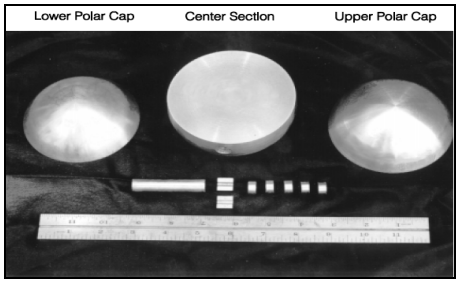
Versions of CED-3b for IER160 and IER 161 have been prepared but not approved.

Further progress for both are awaiting LANL internal technical review of paper on how to handle the uncertainty analysis for sub-critical measurements.

IER 183: Quantifying Uncertainties in Subcritical Neutron Multiplication Inference



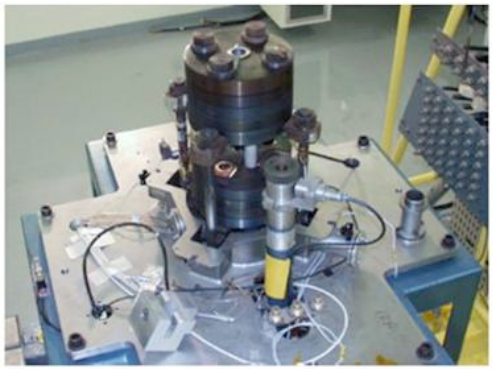
Subcritical measurement campaign using the Thor Core to study sensitivities and how perturbations to mass, glory-hole loadings (amount and location), and source to detector geometry (varying both distance and orientation) affect measurement results.



Subcritical Critical Measurement Technique Refinement and Comparison with CEA Valduc

June 2012 CALIBAN Subcritical Measurement Campaign at Valduc

Data Analysis Exchange Seminar Hosted at Los Alamos in November 2012



Detector Position	Reactivity, from a punctual kinetic study (dollars)	Total Prompt Multiplication (CEA)	Total Prompt Multiplication (LANL)
1	-0.8	saturated	$43.07 \pm 0.23\%$
2	-1	saturated	$79.68 \pm 0.1\%$
2	-1.5	saturated	$69.58 \pm 0.23\%$
2	-2	$65.44 \pm 0.3\%$	$60.39 \pm 0.1\%$
2	-2.5	$46.87 \pm 0.4\%$	-
2	-3	$38.22 \pm 0.3\%$	$47.07 \pm 0.1\%$

Data collected to help validate MCNP detector list-mode simulation subroutine

Status of Other IERs

IER151: NCT Material #2…CED-1 completed

IER153: Measurement of higher energy portion of distribution for neutrons born from fission…Draft CED-1 is being modified.

NCERC Rabbit System: Design requirements document completed and available for review

Note that while Flat-top was declared “operational” in November 2011, we still cannot use the Pu core (or even irradiate Pu samples) because of an Authorization Basis issue associated with the HMI (Human Machine Interface) and measurement of excess reactivity.

Researchers Test Novel Power System For Space Travel (Using Flat-top at NCERC)

LOS ALAMOS, N.M., Nov. 26, 2012—A team of researchers, including engineers from Los Alamos National Laboratory, has demonstrated a new concept for a reliable nuclear reactor that could be used on space flights.
The research team recently demonstrated the first use of a heat pipe to cool a small nuclear reactor and power a Stirling engine at the Nevada National Security Site's Device Assembly Facility near Las Vegas.

The Demonstration Using Flattop Fissions (DUFF) experiment produced 24 watts of electricity. A team of engineers from Los Alamos, the NASA Glenn Research Center and National Security Technologies LLC (NSTec) conducted the experiment. Heat pipe technology was invented at Los Alamos in 1963. A heat pipe is a sealed tube with an internal fluid that can efficiently transfer heat produced by a reactor with no moving parts.

"Perhaps one of the more important aspects of this experiment is that it was taken from concept to completion in 6 months for less than a million dollars," said Los Alamos engineer David Dixon. "We wanted to show that with a tightly-knit and focused team, it is possible to successfully perform practical reactor testing."

Outline

- Integral Experiments
- **Training & Education**
- Nuclear Data
- Information Preservation & Dissemination

LANL T&E Tasking

- LANL staff continually acted upon feedback from the NCSP community and class participants to improve the quality of the presentations and class notes for the teaching modules that LANL was responsible for.

- LANL was responsible for hosting the first week of the two week training course developed by NCSP for Criticality Safety practitioners.

- LANL staff lead the hands on demonstrations at NCERC that utilize the Planet Assembly, the Flat-Top assembly, and BeRP ball as part of the second week training.

- LANL staff taught various modules as part of both weeks of the training and administered the testing of the students for both weeks of the two week Criticality Safety practitioners class.

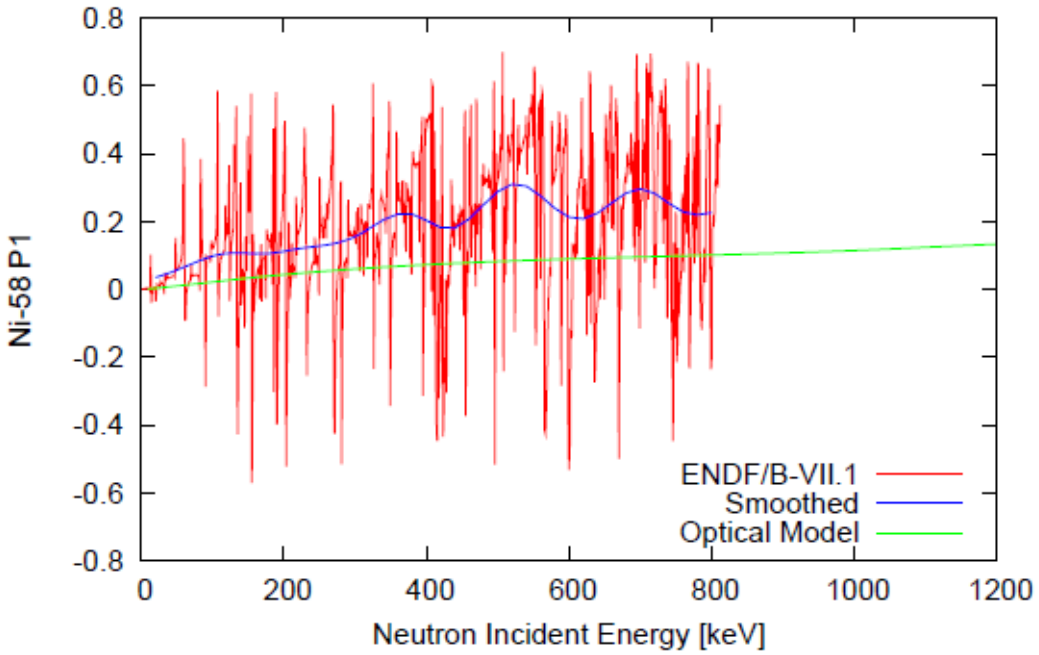
LANL T&E Tasking (continued)

- LANL staff helped develop the agenda, presentations, and class notes for the one week Criticality Safety course for Managers.
- LANL Staff helped teach and execute the pilot criticality safety course for managers at NCERC.
- LANL successfully executed its portion of all scheduled classes in FY 2012 and FY 2013 where its participation was planned (except for one “hands on” class at NCERC that had to be rescheduled due to some operational anomalies encountered with the Planet and Flat-top assemblies).

Outline

- Integral Experiments
- Training & Education
- **Nuclear Data**
  - Input from: J.L. Conlin, S.J. Gardiner, G.M. Hale, A.C. (Skip) Kahler, T. Kawano, M.B. Lee, D. Neudecker, M.W. Paris, D.K. Parsons, M.E. Rising, I. Stetcu, P. Talou, and M.C. White
- Information Preservation & Dissemination

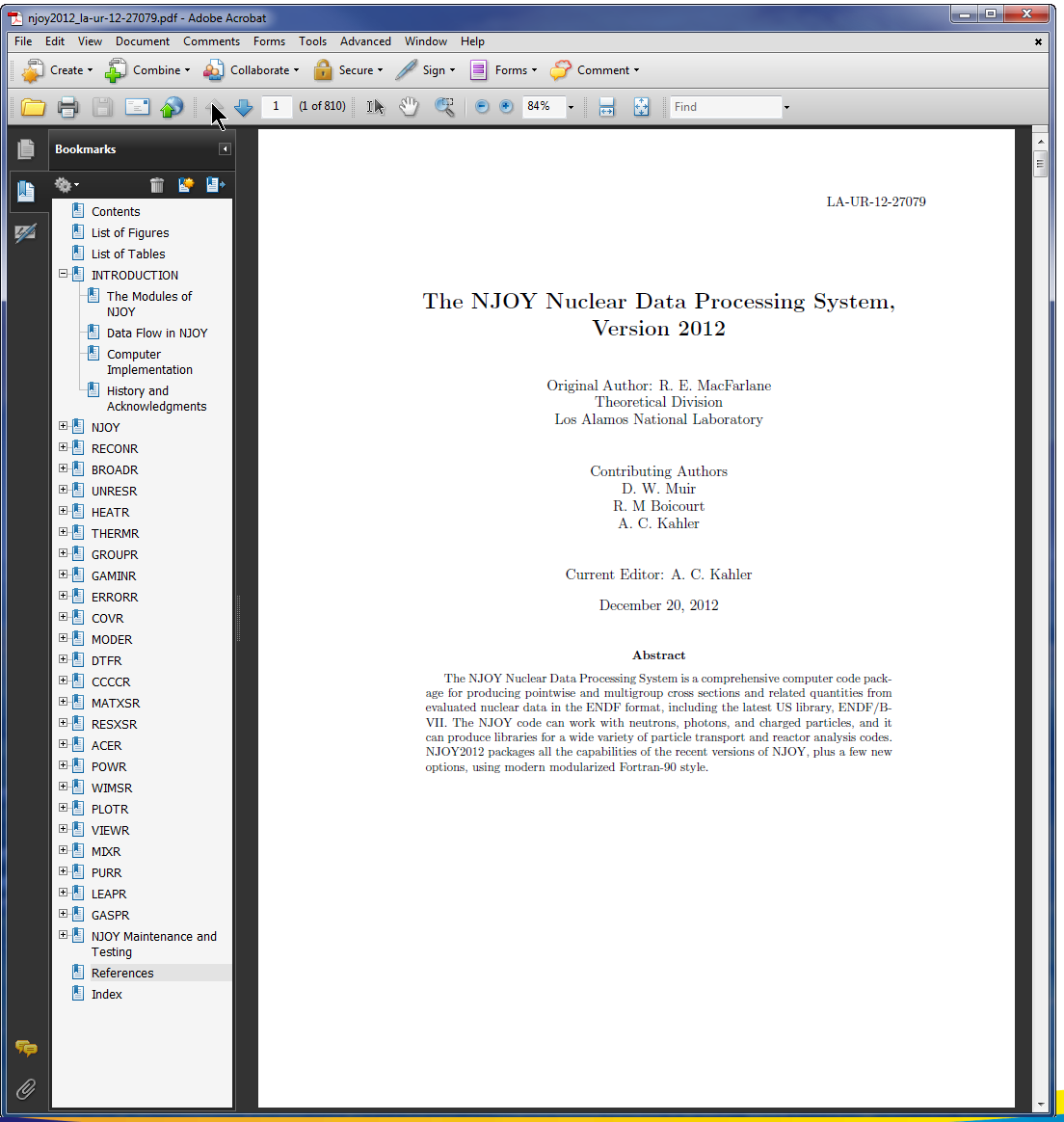
Revised Elastic Scattering Angular Distributions



Revised Ni evaluations including improved angular distributions have been sent to NNDC for 6 isotopes (58-62, and 64). Ni-59 is an almost new evaluation

- Green Curve is ENDF/B-VII.1 (Optical Model).
- Red curve is a detailed distribution from ENDF/B-VII.1 resonance parameters.
- Blue curve is a Gaussian smoothed distribution.
  - This distribution appears in the revised ^{iso}Ni evaluated files.
- Calculated eigenvalue impact
  - HMF3.12, a nickel reflected HEU sphere:
    - ENDF/B-VII.1 k_{calc} is ~1.009.
    - ENDF/B-VII.1 + revised Ni angdist (blue curve) k_{calc} is ~0.998.

NJOY2012 Released



- Hyperlinked pdf manual
  - Numerous example input decks and detailed code flow description
  - 128 References to Current and Past Reactor Physics Theory and Methods
  - http://t2.lanl.gov/nis/codes/NJOY12/index.html
- Handles recently defined Hybrid R-Function (LRF=7)
  - NJOY99 does not
- Extended flexibility for multi-temperature and multiple self-shielding jobs.
- Modern Fortran 90 and later coding
  - More robust, flexible and easier to maintain than the FORTRAN77 based version.

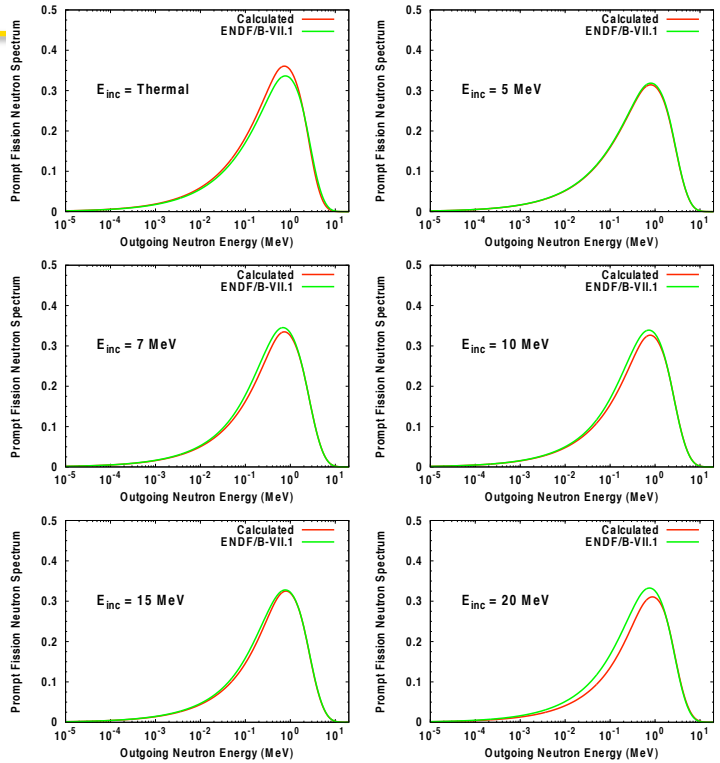
ENDF71x – ENDF/B-VII.1 Based ACE Data Tables for MCNP

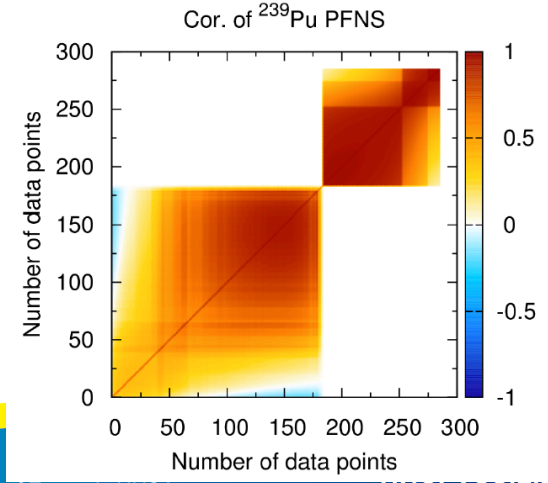
- 423 Evaluations
- 7 Temperatures
  - 293.6 K
  - 600 K
  - 900 K
  - 1200 K
  - 2500 K
  - 0.1 K
  - 250 K

- Processed with NJOY99.393
- Documented in LA-UR-13-20137
- Extensively Tested with both MCNP5 and MCNP6
- Also, 715 Critical Benchmarks
  - 4232 CPU hours
- Deployed at Los Alamos
- Will be part of the MCNP6 production release package to RSICC

Prompt Fission Neutron Spectrum

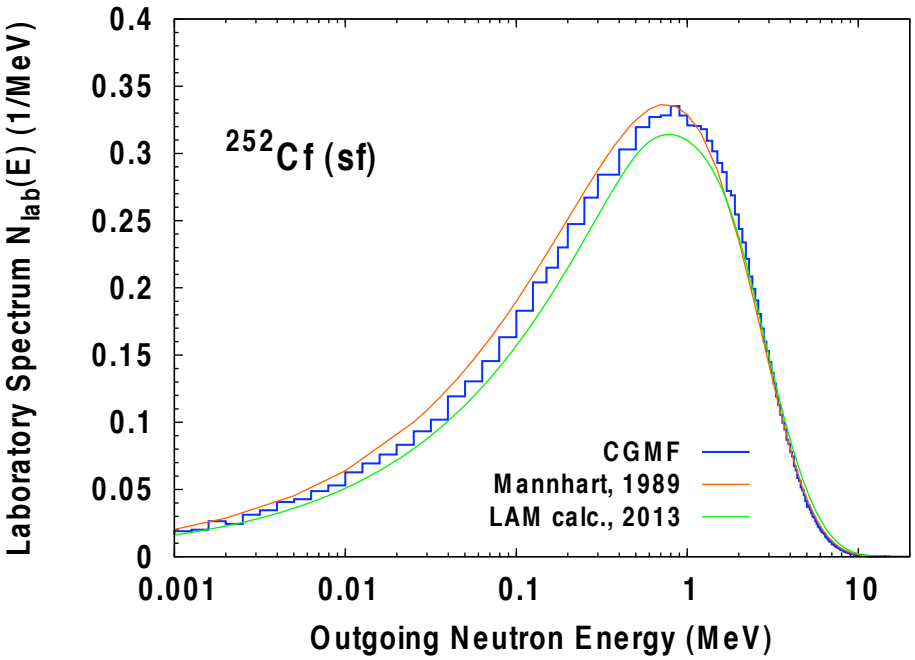
- Model
  - Modified “Los Alamos” model
  - Includes anisotropy and different light and heavy fragment <n>
  - To be linked with CoH nuclear reaction code for high-E_{inc} contributions
- UQ
  - KALMAN
  - New code by D.Neudecker
- Experimental Covariance Matrices
  - New code and analysis
  - Vastly improved matrices!
  - Work closely with Chi-Nu experimentalists at LANSCE
- Note that LANL delivered updated PFNS for minor actinides in FY12 using earlier version of this capability and systematics.

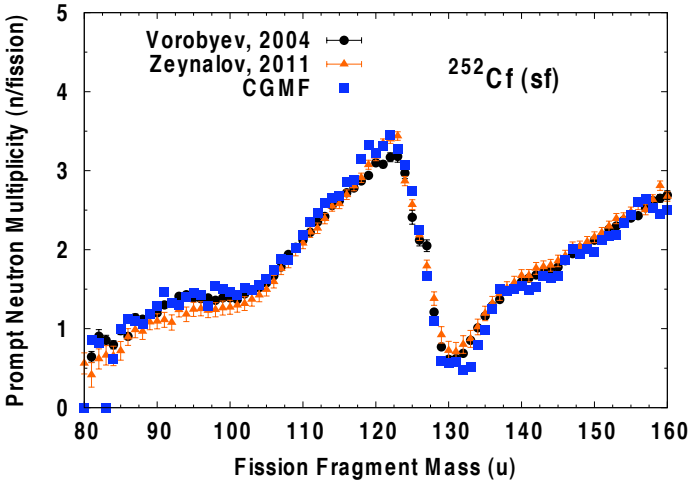




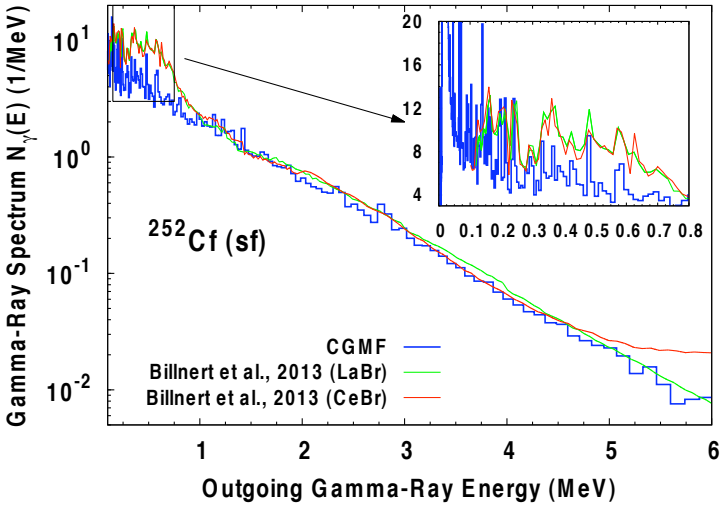
Prompt Fission Neutron Spectrum

- Traditional "Los Alamos" model being replaced by advanced **Monte Carlo Hauser-Feshbach (MCHF) simulations**



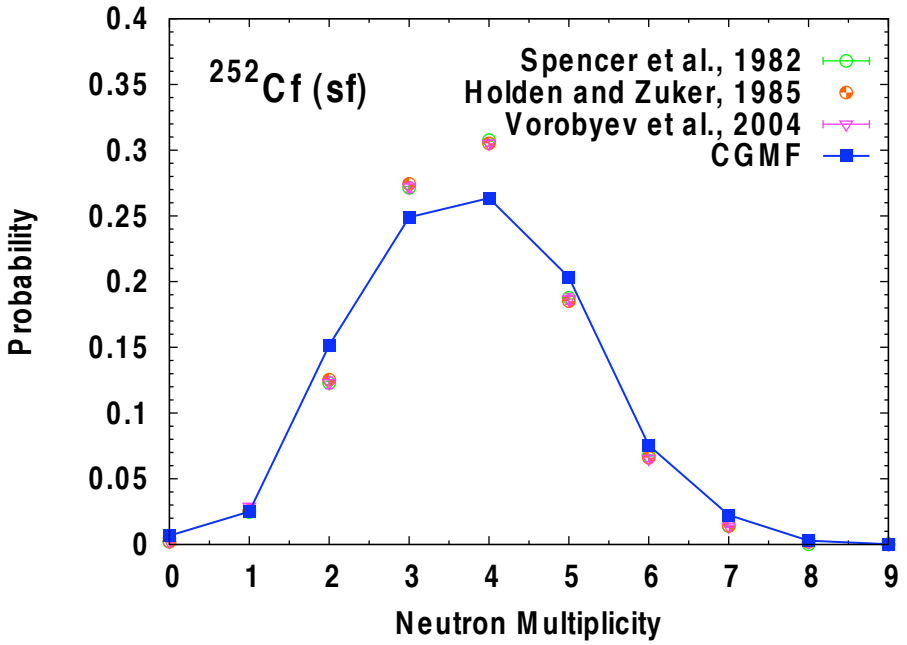


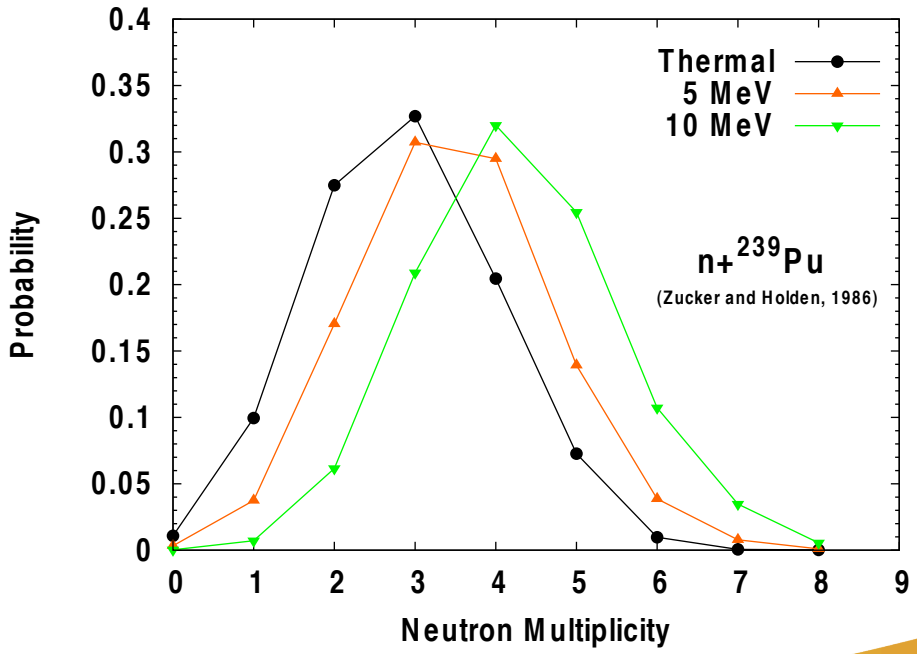
Predictions for other Prompt Fission Neutron (PFN) data, as well as prompt fission photons! →



P(ν)

- Can be calculated with CGMF (see ^{252}Cf spontaneous fission [below left])
- Very little is known about incident neutron energy dependence
- We will deliver p(ν) data for U235, U-238, and Pu-239 to NNDC before end of FY



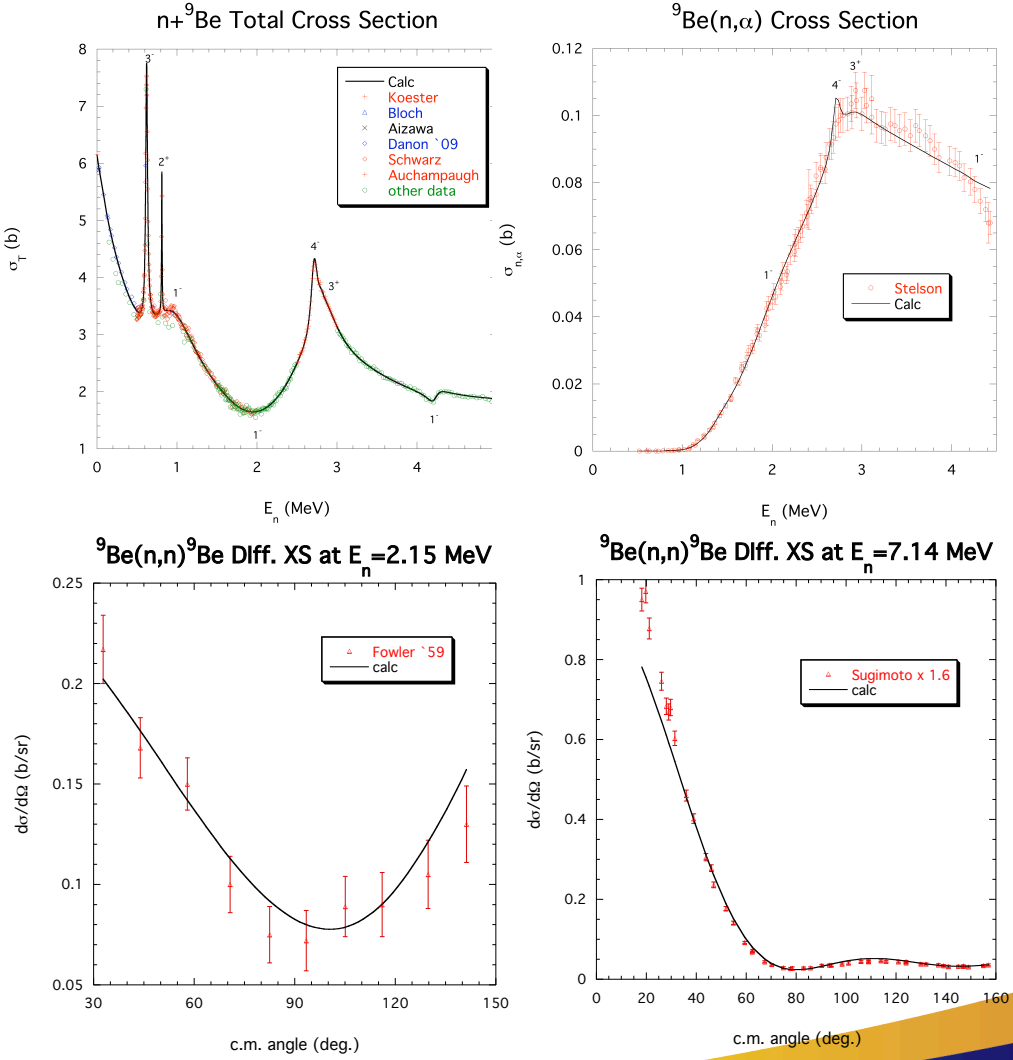


n + ^{9}Be (^{10}Be System) Analysis

3-Channel Analysis (n+^{9}Be, α+^{6}He*, nn +^{8}Be*):

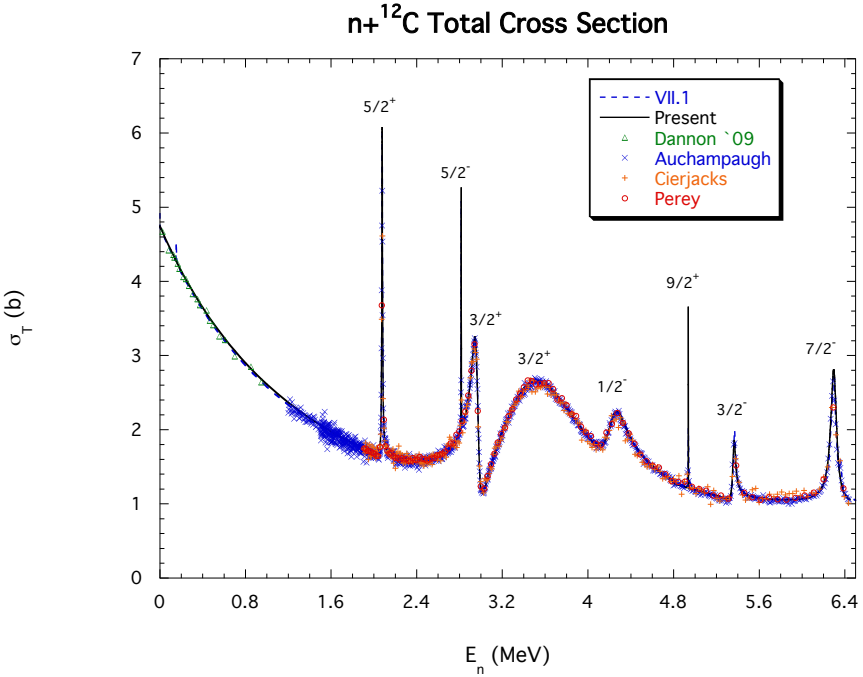
- Total, (n,α) cross sections well fit; more (n,2n) absorption needed for E_n > 3 MeV.

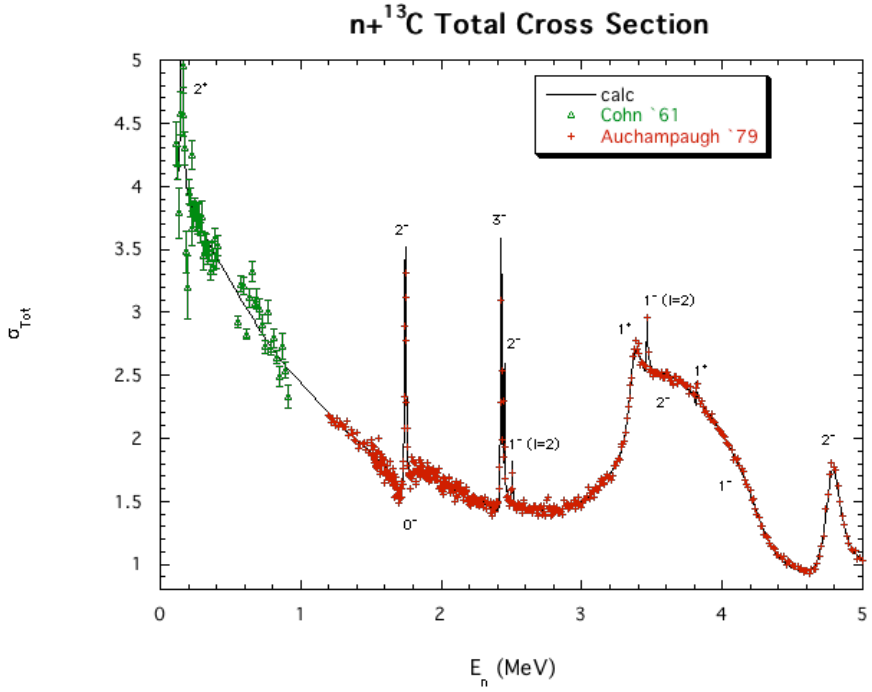
- Elastic scattering angular distributions added to the fit. Normalizations are off for E_n > 4 MeV, but shapes are mostly OK.



n + ^{12,13}C (^{13,14}C Systems) Analyses

Done to separate the natural C evaluation into its isotopic components. Analyses include angular distribution data and covariances. The ^{13}C analysis was reported at ND2013.





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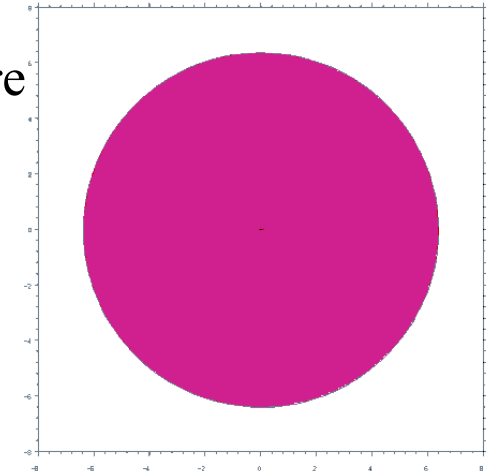
Jezebel Reevaluation



- Jezebel is a one-dimensional homogeneous bare sphere critical plutonium benchmark:
  - Radius 6.3849 cm
  - Density 15.61 g/cm^3
  - Mass 17,020 ± 100 g Pu alloy
  - k_{eff} = 1.000 ± 0.002

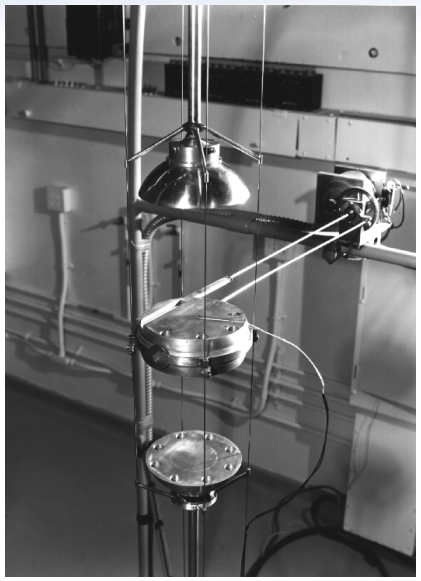
- The initial experiments were performed in 1954-1955. Results were published in *Nucl. Sci. Eng.* in 1960.

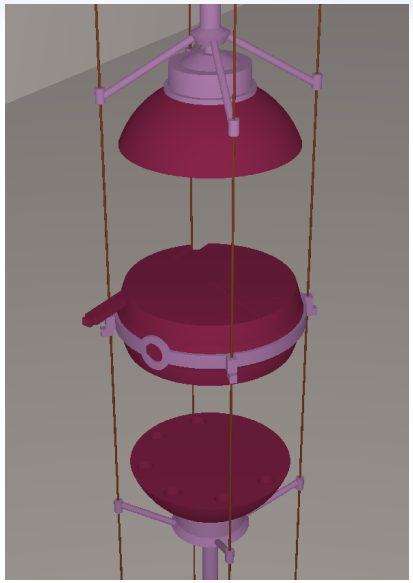
- The benchmark specifications above, currently used worldwide, came from a 1969 Los Alamos report, LA-4208 (a homogenized density was calculated).

- Using LA-4208 as well as logbooks, drawings, and internal memoranda, we reevaluated Jezebel using four extremely detailed models.

Jezebel Reevaluation: Four Detailed Configurations

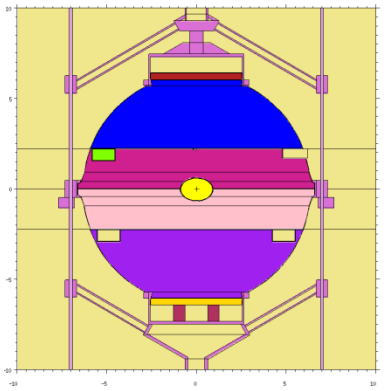
- The four Jezebel configurations differ in the number of internal mass adjustment buttons, the presence of polar end caps, and the control rod position.

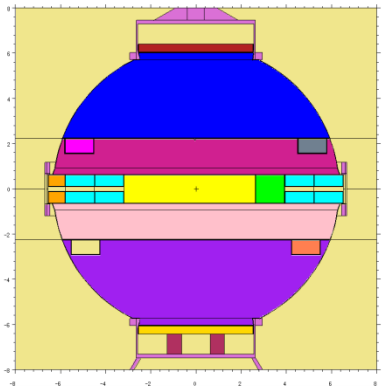




	Experimental k_{eff}	Calc./Exp.
Config. A	0.99999 ± 0.00123	1.00073 ± 0.00123
Config. B	1.00016 ± 0.00123	1.00099 ± 0.00123
Config. C	1.00020 ± 0.00123	1.00074 ± 0.00123
Config. D	1.00128 ± 0.00123	1.00062 ± 0.00123
Average	N/A	1.00077
Std. Dev.	N/A	0.00016

- A detailed uncertainty analysis was performed using the three-dimensional configurations.
  - The ±0.00123 is still being evaluated.





- We used MCNP6 with ENDF-B/VII.1.

Jezebel Reevaluation: Results

- New one-dimensional homogeneous bare sphere critical plutonium benchmark:
  - Radius 6.3849 cm → 6.39157 cm
  - Density 15.61 g/cm^3 → 15.61 g/cm^3
  - Mass 17,020 ± 100 g Pu alloy → 17,073.2 ± 73 g Pu alloy
  - k_{eff} = 1.000 ± 0.002 → 1.00077 ± 0.00123

- ENDF/B-VII was tuned to the original one-dimensional Jezebel.
  - If the data were retuned to compute k_{eff} =1 for the new one-dimensional Jezebel, then it should compute C/E ≈ 1 for the four detailed models.

- The reevaluated Jezebel was accepted by the International Criticality Safety Benchmark Evaluation Project Working Group, pending minor revisions to the text and some analyses, at their May 2013 meeting in Paris.
  - The evaluator also participated in reviews of 11 other evaluations at the working group meeting.

- Summaries and papers are being written for upcoming ANS meetings.

Summary

- We have presented a brief summary of recent LANL NCSP highlights in
  - Integral Experiments
  - Training & Education
  - Nuclear Data
  - Information Preservation & Dissemination
- Questions?